FIRST AUSTRALIAN RECORDS OF *EUPLOEA WALLACEI MELIA* FRUHSTORFER, 1904 AND *EUPLOEA STEPHENSII JAMESI* BUTLER, 1876 (LEPIDOPTERA: NYMPHALIDAE: DANAINAE) FROM DAUAN ISLAND, TORRES STRAIT, QUEENSLAND, WITH NOTES ON THE AGGREGATION HABITS OF *EUPLOEA* FABRICIUS SPECIES NEAR FLOWERING MANGROVES

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Abstract

Euploea wallacei melia Fruhstorfer, 1904 and *E. stephensii jamesi* Butler, 1876 are recorded from Dauan Island, Torres Strait, Queensland for the first time, bringing the number of *Euploea* Fabricius species recorded from the island to ten. A large wet season roosting of danaines, predominantly *Euploea* spp, was observed on Dauan Island in late December 2009 and early January 2010. The aggregation clustered near flowering trees of the White-flowered Black Mangrove, *Lumnitzera racemosa* (Combretaceae). Two humid mangrove glades with large amounts of *L. racemosa* flowers were preferred loci for the 10 *Euploea* species encountered, with several hundred butterflies observed feeding on blossom or roosting in each of the glades at any one time. Most of these individuals were newly emerged. Butterflies roosted overnight in the glades prior to feeding on *L. racemosa* flowers the following morning. This congregation of *Euploea* butterflies within the mangrove blossom environment was temporary, as butterfly numbers declined markedly by the middle of January 2010, after cessation of the mangrove blossom. Communal roosting by *Euploea* at nectar sources is previously unrecorded in Australia and this phenomenon is suggested to be the result of newly emerged butterflies at the start of the wet season migrating from their breeding environments to feed at discrete, nectar-rich areas.

Introduction

The summer monsoon season is a key weather event for much of northern Australia, including the islands of Torres Strait in northern Queensland (Bowman *et al*. 2010). The onset of the season is characterised by a southerly moving band of low pressure systems (Fig. 1), which generates moist northwesterly winds that variably begin between late November and late January (Jones 1987) and persist until April or May.

On Dauan, one of the most northerly of the Torres Strait islands, the dominant vegetation types are deciduous monsoon forest and semi-evergreen mesophyll vine forest (Webb 1959, Torres Strait Regional Authority 2013), which grow extensively among exposed granite boulders (Fig. 2). The highest part of this boulder stack is Mt Cornwallis, at approximately 300 m. Crow butterflies, *Euploea* Fabricius, 1807, are commonly observed during the wet (monsoon) season on Dauan Island. *Euploea* species are essentially tropical in distribution, occurring in the Oriental and Australian regions (Ackery and Vane-Wright 1984, Scheermeyer 1999), with the greatest diversity in the Indo-Australian region (Corbet and Pendlebury 1992, Ackery

and Vane-Wright 1984, Parsons 1998), particularly on Java and Sumatra and in New Guinea (Kitching and Scheermeyer 1993, Scheermeyer 1999).

Eight species of *Euploea* have been recorded from Dauan Island to date, *viz. E. algea amycus* Miskin, 1890, *E. sylvester sylvester* (Fabricius, 1793), *E. alcathoe misenus* Miskin, 1890, *E. tulliolus dudgeonis* (Grose-Smith, 1894), *E. batesii batesii* C. & R. Felder, 1865, *E. corinna* (W.S. Macleay, 1826), *E. netscheri erana* (Fruhstorfer, 1910) and *E. leucostictos* (Gmelin, 1790).

In early January 2010, *E. wallacei melia* Fruhstorfer, 1904 and *E. stephensii jamesi* Butler, 1876, two species previously unrecorded from Australia, were collected from within mangrove glades adjacent to flowering trees of the White-flowered Black Mangrove, *Lumnitzera racemosa* (Combretaceae).

Lumnitzera racemosa (Fig. 3) is a tropical and subtropical species (Lear and Turner 1977, Williams 1987) that occurs commonly in the low-lying areas on the eastern and western ends of Dauan Island (Figs 4-5) and typically flowers within the first month after the onset of the monsoon or wet season. In the last week of December 2009, through to the second week of January 2010, *L. racemosa* flowered quite profusely and attracted large numbers of danaine butterflies, including *Danaus affinis affinis* (Fabricius, 1775) (Fig. 6), *Tirumala hamata hamata* (Macleay, 1827) and, in particular, several *Euploea* species.

Considering the diversity of *Euploea* in New Guinea, with at least 16 species known (Yata and Morishita 1985, Parsons 1998, Scheermeyer 1999) and the proximity of Torres Strait to New Guinea, it is not surprising that 10 species are now recorded from Dauan Island. This brings the total number of *Euploea* species now known from Torres Strait islands to 12 (Braby 2000, Meyer *et al.* 2004, Lambkin and Knight 2007).

A critical survival strategy for several *Euploea* species and other danaine species in monsoon regions is to aggregate or roost, often in large communities and typically over the dry season (Kitching and Zalucki 1981, Scheermeyer 1993, Canzano *et al.* 2003). Typically, individuals within these aggregating communities persist in a semi-quiescent state for the duration of the dry period. These aggregations can be semi-permanent in their roosting locations and revisited over several dry seasons (Monteith 1982). In contrast to this dry season behaviour, here I document an opportunistic, wet season roosting of *Euploea* and other danaines near nectar sources on Dauan Island in late December 2009 and early January 2010. The aggregating *Euploea* species included the two previously unrecorded from Australia.

The following abbreviations refer to public institutions and private collections from which material was examined: MDBC – M. De Baar collection (*Euploea* spp now in TLIKC); QDAFC – Queensland Department of Agriculture and Fisheries collection, Brisbane; TLIKC – Joint collection of T.A. Lambkin and A.I. Knight, Brisbane.

Figs 1-8. (1) Monsoon cloud band over northern Australia, 9.i.2014 (Australian Government, Bureau of Meteorology); (2) hill on western end of Dauan composed of granite boulder stacks; (3) flowering *Lumnitzera racemosa* on Dauan; (4) northern aspect of western end of Dauan, panhandle covered mostly with mangroves; (5) aerial view of southern aspect; (6) *Danaus affinis affinis* visiting blossom of *L. racemosa*; (7) mangrove glade on Dauan after termination of flowering; (8) male *Euploea alcathoe misenus* roosting under *Rhizophora stylosa* in mangrove glade.

Abbreviations of collectors' names appearing on specimen labels are: GS – collector unknown; IFTA – Insect Farming and Trading Agency, Bulolo, Papua New Guinea; JFG – J.F. Grimshaw; JG – J. Guyomar; JH – J. Hancox; PS – P. Shanahan; RS – R. Straatman; TAL – T.A. Lambkin.

Specimens examined

Euploea wallacei C. & R. Felder, 1860

(Figs 9-14)

QUEENSLAND: 1 ♂, Dauan Island, Torres Strait, 9°25'S 142°32'E, 9.i.2010, TAL (TLIKC); 1 ♀, same data except 10.i.2010 (TLIKC).

PAPUA NEW GUINEA: 1 ♂, Kiunga, Western Province, -.ii.1991, JH (TLIKC, ex MDBC); 1 ♂, Lae, Morobe Province, -.ix.1969, GS (TLIKC, ex MDBC); 7 ♂♂, 1 ♀, Sambio Mumeng, Morobe Province, -.xii.1984 (2 ♂♂), -.i.1985 (4 ♂♂), -.v.1985 (1 ♂, 1 ♀), IFTA (TLIKC, ex MDBC); 2 ♂♂, Wau, Morobe Province, 1200 m, 24.x.1975 (TLIKC, ex MDBC); 1 ♀, same data except -.iv.1974, PS (TLIKC, ex MDBC).

INDONESIA: 2 ♂♂, Halmahera I., Northern Moluccas, -.vi.1996 (TLIKC, ex MDBC); 1 ♂, 1 ♀, Dobo, Wamar I., Aru Is, 1992 (TLIKC, ex MDBC); 1 ♂, Manokwari, West Papua Province, 1989 (TLIKC, ex MDBC).

Euploea stephensii C. & R. Felder, [1865]

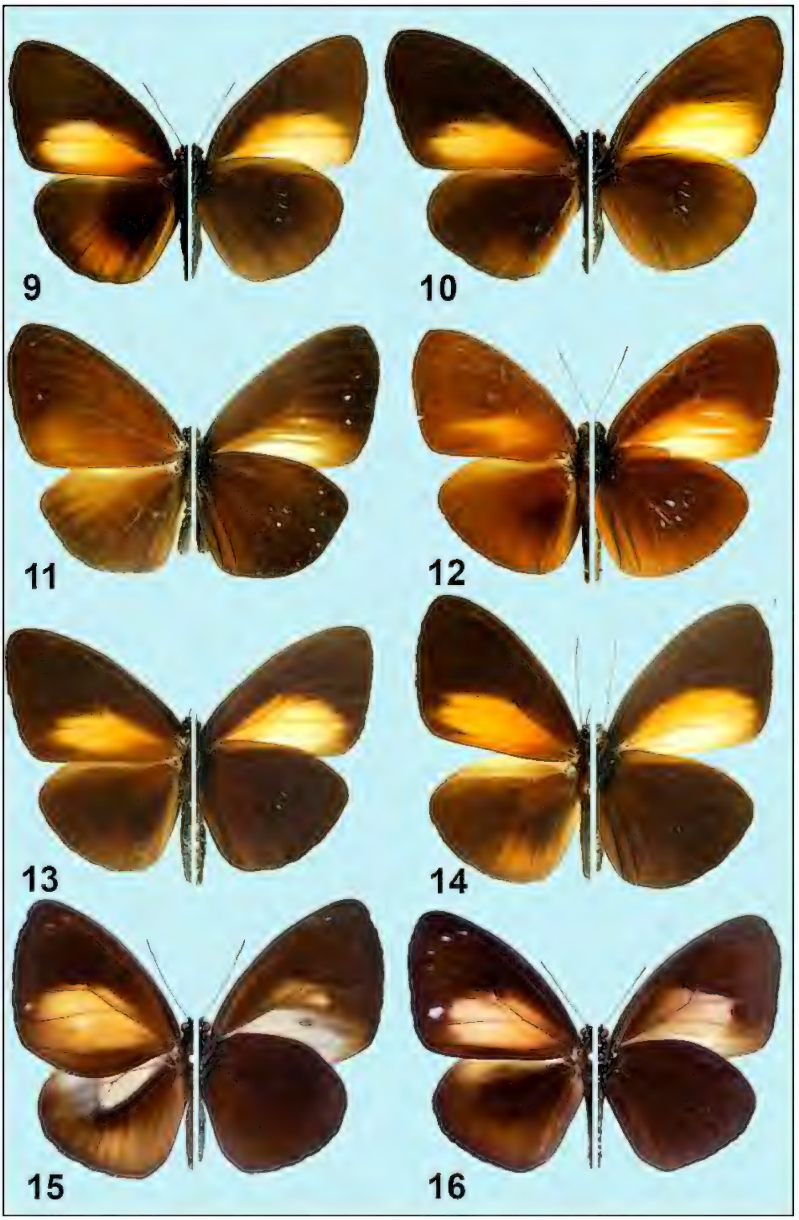
(Figs 17-20)

QUEENSLAND: 1 ♀, Dauan Island, Torres Strait, 9°25'S 142°32'E, 9.i.2010, TAL (TLIKC).

PAPUA NEW GUINEA: 1 ♂, Imonda, West Sepik Province, 15.v.1992, JFG (QDAFC); 1 ♀, Nuku Mission, NW Central Highlands Province, -.viii.1977 (TLIKC, ex MDBC); 1 ♂, Lae, Morobe Province, 10.xii.1969, GS (TLIKC, ex MDBC); 1 ♀, Sambio Mumeng, Morobe Province, -.xii.1984, IFTA (TLIKC, ex MDBC); 1 ♂, Janita Village, 10 km E of Popondetta, Oro Province, 22.x.1987, JG (TLIKC, ex MDBC).

INDONESIA: 1 ♂, Kofiau I., N of Misool I., 1992 (TLIKC, ex MDBC); 1 ♂, Waigeo I., 26.ix.1985, RS bequest (TLIKC, ex MDBC); 1 ♂, sama data except 2.x.1985, RS (TLIKC, ex MDBC); 1 ♂, Yapen I., Irian Bay, Papua Province, -.i.1996 (TLIKC, ex MDBC); 1 ♂, Nabire, Papua Province, -.x.1991 (TLIKC, ex MDBC); 1 ♀, Jaya Pura, Papua Province, 1989 (TLIKC, ex MDBC).

Figs 9-16. *Euploea* spp. All figures not to scale: upperside left, underside right [forewing lengths, in mm, in square brackets]. (9-14) *E. wallacei*: (9, 10, 13, 14) *E. w. melia*; (9-10) Dauan I., Torres Strait, Qld, (9) ♂, 9.i.2010 [43 mm], (10) ♀, 10.i.2010 [40]; (13) ♂, Wamar I., Dobo, Aru, 1992 [38]; (14) ♂, Wau, Morobe Province, PNG, 24.x.1975 [40]; (11-12) *E. w. wallacei*: (11) ♂, Halmahera I., Northern Moluccas, -.vi.1996 [42]; (12) ♂, Manokwari, West Papua Province, 1989 [38]. (15-16) *E. leucostictos*: Dauan I., Torres Strait, Qld, 9.i.2010, (15) ♂ [42], (16) ♀ [45].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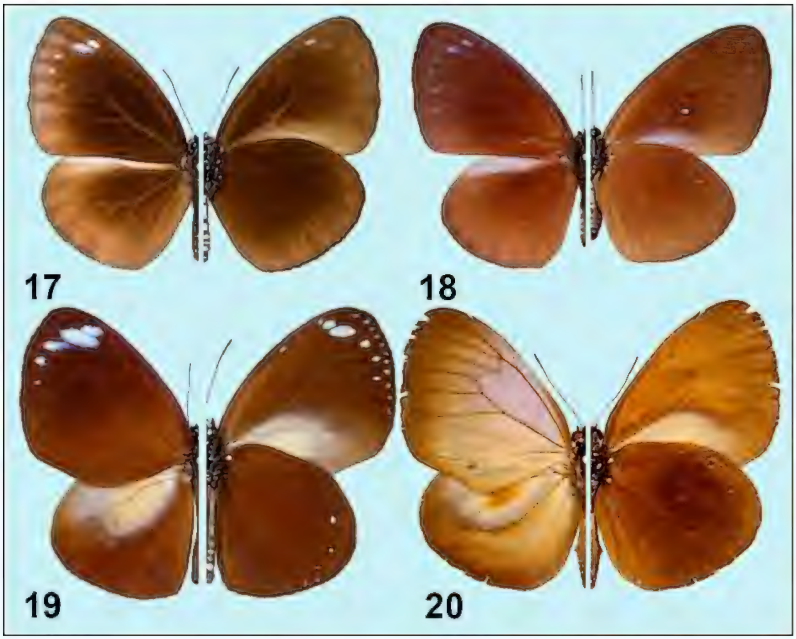

Figs 17-20. *Euploea stephensii*. All figures not to scale: upperside left, underside right [forewing lengths, in mm, in square brackets]. (17-19) *E. s. jamesi*: (17) ♀, Dauan I., Torres Strait, Qld, 9.i.2010 [35 mm]; (18) ♀, Jaya Pura, Papua Province, Indonesia, 1989 [36]; (19) ♂, Janita Village, 10 km E of Popondetta, Oro Province, PNG, 22.x.1987 [30]. (20) *E. s. pumila* Butler, 1866: ♂, Imonda, West Sepik Province, PNG, 15.v.1992 [30] (courtesy of QDAFC).

Field observations

Two humid mangrove glades (Fig. 7), with large numbers of *L. racemosa* flowers, were preferred loci for several species of *Euploea*, with several hundred butterflies observed in each glade at any one time, feeding especially at flowers of several taller *L. racemosa* trees in each glade. The *Euploea* species were observed mostly between the hours of 0800h and 1000h Australian Eastern Standard Time (AEST) and again from about 1400h to 1600h AEST. Large numbers of *Euploea* were also observed communally roosting on branches and dead sticks within mature *L. racemosa* trees and on other large mangrove trees *Rhizophora stylosa* Griff. (Rhizophoraceae) and *Avicennia marina eucalyptifolia* (Valeton) J. Everett (Acanthaceae) (Fig. 8). In addition, hundreds of *Euploea* were observed communally roosting in these loci prior to 0800h AEST and it is likely that they roosted there overnight, prior to feeding from *L. racemosa* flowers the following morning.

By the middle of January 2010, after cessation of the mangrove blossom, the numbers of *Euploea* declined markedly within the glades, indicating the aggregation's opportunistic nature and its direct link to the nectar source. In previous years on Dauan Island (*i.e.* Januaries of 2006 and 2008), *Euploea* species were observed by the author around *L. racemosa*, but the abundance of flowers and butterflies and the *Euploea* species diversity observed in the two mangrove loci in December 2009 and January 2010 were unprecedented. In addition, other regular communal roosting haunts of many *Euploea* observed that same year and in previous wet seasons have been in the island village, around and under flowering trees of *Terminalia catappa* F. and *T. muelleri* Benth. (Combretaceae) and *Citharexylum spinosum* L. (Verbenaceae), but again not in the large numbers observed in the mangrove glades in December 2009 and January 2010.

The majority of *Euploea* species observed in the summer of 2009-2010 were those that are often seen on Dauan Island, particularly during the wet season, *viz. E. algea amycus*, *E. sylvester sylvester*, *E. alcathoe misenus* (taxonomy as per Lambkin 2005, Braby 2016) (Fig. 8) and *E. tulliolus dudgeonis* (taxonomy as per Lambkin and Knight 2007). What was unusual in 2009-2010 was the occurrence of some *Euploea* species that are not often observed on the island, *viz. E. batesii batesii* (taxonomy as per Lambkin 2013, Braby 2016), *E. corinna* (taxonomy as per Braby 2010), *E. netscheri erana* and *E. leucostictos* (Lambkin and Knight 2007), with the latter two being relatively abundant (24 and 30 specimens collected respectively) inside and around the two mangrove loci, either roosting or feeding on nectar of *L. racemosa*.

Within these mangrove glades, a male and female of *E. wallacei melia* (Figs 9-10) were collected feeding at *L. racemosa* blossom in company with *E. leucostictos* (Figs 15-16); one was collected in the morning of 9 January (at approximately 0900h AEST) and the other in the afternoon of 10 January (at approximately 1500h AEST).

On 9 January, a single female of *E. stephensii jamesi* (Fig. 17) was collected in the afternoon (at approximately 1500h AEST), as it perched on an inner branch of *Rhizophora stylosa* just beneath blossoming trees of *L. racemosa*.

The majority of *Euploea* specimens collected and observed on Dauan Island during that particular week were in fresh condition, suggesting they were newly emerged.

Euploea wallacei melia Fruhstorfer, 1904

Euploea wallacei occurs in the Moluccas from Halmahera to Buru and eastward on Aru, Waigeo, Mysol, Salawati, Biak, Japen, Roon, mainland New Guinea and several of its outlying islands, including Daru, to Fergusson Island (Ackery and Vane-Wright 1984, Parsons 1998). Across its range, the species is phenotypically variable from west to east, with western populations of *E. w. wallacei* from the Moluccas and *E. w. confusa* Butler, 1866 from

Indonesian Papua being mostly black or dark brown in colour (Figs 11-12). Further east in Papua New Guinea, as *E. w. melia* (Figs 13-14), the species occurs mostly as a black butterfly with conspicuous 'orange windows' on the forewings (Ackery and Vane-Wright 1984). This black and orange form is similar to the '*usipetes*' form of *E. leucostictos* (Figs 15-16), which is another polymorphic species with a similar black and orange morph found predominantly in southern Papua New Guinea (Parsons 1998, Lambkin and Knight 2007). *Euploea leucostictos* has a much broader range, from the Andaman Islands and southern China to the Solomon Islands (Yata and Morishita 1985).

In Papua New Guinea *E. wallacei* frequents forests and forest margins where it is often encountered with the '*usipetes*' form of *E. leucostictos* (Ackery and Vane-Wright 1984, Parsons 1998). Little is known of its life history although D'Abrera (1978) and Parsons (1998) recorded *Ficus* sp. (Moraceae) and *Parsonsia* sp. (Apocynaceae) respectively as larval host plants.

Due to the similarity of *E. w. melia* and *E. leucostictos* (form '*usipetes*'), the latter is thought to be a Batesian mimic of *E. w. melia* (Parsons 1998). *Euploea w. melia* can be distinguished from females of orange forms of *E. leucostictos* by the presence of elongate white stripes in the spaces above 1A+2A and CuA_2 of the forewing underside, and by the presence of a series of centrally placed blue spots or streaks (3-5) on the hindwing underside (Figs 9-14). In addition, females of *E. leucostictos* always bear at least a single white spot in the subterminal area of the forewing upperside (Fig. 16) (Lambkin and Knight 2007). *Euploea w. melia* is one of the few species of *Euploea* where the posterior margin of the male forewing is straight rather than bowed or convex (Ackery and Vane-Wright 1984). The species was placed into one of three clades (*i.e.* Clade 211.3) but, in doing so, Ackery and Vane-Wright (1984) suggested that this arrangement was at best tentative, as *E. wallacei* was the only species in this clade where the posterior margin of the male forewing was not strongly convex.

Despite the widespread distribution of *E. wallacei* across New Guinea (Ackery and Vane-Wright 1984, Parsons 1998) and the proximity of Torres Strait to southern Papua New Guinea, the species has not been recorded previously from the northern Torres Strait islands.

***Euploea stephensii jamesi* (Butler, 1876)**

Euploea stephensii primarily occurs in mainland New Guinea but does extend westwards to the Maluku Islands in the Northern Moluccas of Indonesia (and including Waigeo and Yapen Islands) and eastwards to New Britain and the Bismarck Archipelago in Papua New Guinea (Ackery and Vane-Wright 1984, Parsons 1998). In Papua New Guinea the species is widespread (Parson 1998) and frequents forest margins, including secondary forest up to about 1000 m (Ackery and Vane-Wright 1984, Parsons 1998).

Parsons (1998) briefly studied the life history of *E. s. jamesi* in Bulolo, Morobe Province, Papua New Guinea, where he reared larvae on *Trophis scandens* (Lour.) Hook. & Arn. (Moraceae). Although Parsons (1998) illustrated a final instar larva, the image was unfortunately referred to twice in his text as either *E. tulliolus dudgeonis* or *E. s. jamesi* and referred to as *E. tulliolus* (Fabricius, 1793) in the plate caption. Despite Parsons' (1998) illustration resembling closely the final instar larva of *E. t. tulliolus* from Brisbane, Queensland (Lambkin 2010), it might well have been of *E. s. jamesi*, considering that the two species are thought to be closely related (Ackery and Vane-Wright 1984).

Euploea stephensii is also phenotypically variable across its range and has a large number of subspecies (Parsons 1998). In the northern half of Papua New Guinea, individuals of *E. stephensii* can be remarkably different in colour (Fig. 20), with some females being a pale blue-silver on the upperside of the wings (*E. s. pumila* f. *lucinda* Grose-Smith, 1894). In the south of Papua New Guinea, individuals of *E. s. jamesi* show little polymorphism (Figs 18-19) and resemble *E. tulliolus*, but can be distinguished from the latter by the shape of their forewings, being more squat and vertically broader (Parsons 1998). This similarity prompted Ackery and Vane-Wright (1984) to group these two species, plus *E. hewitsoni* Felder & Felder, [1865] and *E. darchia* (Macleay, 1827), into a '*tulliolus*-complex', which they tentatively classed as a 'clade' [or more correctly as an 'informal group' as per the International Commission on Zoological Nomenclature 'Code' (ICZN 1999)]. Ackery and Vane-Wright (1984) admitted that their assemblage of the four taxa into this complex was poorly characterised and that the only significant feature of the group they could determine was its 'unique exploitation' of *T. scandens* as a larval host plant.

Finally, populations of *E. wallacei*, *E. leucostictos* and *E. stephensii* all show diverse phenotypic variation across their geographic ranges (Ackery and Vane-Wright 1984, Parsons 1998, Lambkin and Knight 2007). This, combined with the difficulty in defining their cladistic placement (Ackery and Vane-Wright 1984), suggests that these taxa could be further examples of species complexes within the genus *Euploea*, thereby highlighting the difficulties confronted in attempting to unravel these complexes (*e.g.* Ackery and Vane-Wright 1984, De Baar 1991, Vane-Wright 1993, Lambkin 2001, 2005, 2013, Lambkin and Knight 2007, Monastyrskii 2011, Tennent 2001, Treadaway 2012, Yata and Morishita 1985).

Discussion

One of the features of *Euploea* butterflies in Torres Strait, particularly on Dauan Island, is their often relative abundance soon after the commencement of the monsoon rains and their relative scarcity at other times, chiefly during the dry season. Thus, after the end of the wet season, numbers of *Euploea*

noticeably decline on Dauan Island and those surviving enter a reproductive diapause (Canzano *et al.* 2003).

Euploea species in the monsoon tropics can typically enter diapause during the dry season and are known to communally aggregate or roost, quite often in large numbers, in protected areas such as shaded gullies, caves and under evergreen thickets of mangroves and bamboo, most often adjacent to water (Kitching and Zalucki 1981, Monteith 1972, 1982, Scheermeyer 1993, Canzano *et al.* 2003).

With the onset of the wet season across Torres Strait and southern Papua New Guinea come conditions that likely act as cues to end this diapause (Canzano *et al.* 2003), resulting in adult roosting butterflies becoming active and reproductive. Consequently, these individuals that have undergone diapause give rise to the next generation of *Euploea*, observed on Dauan Island as a peak during the first month of the wet season (Lambkin and Knight 2007). Based on life table data for several other Australian *Euploea* species (Meyer 1996, 1997, Lambkin 2001, 2010, Braby 2009) and the fact that diapausing adults become reproductive again after the start of the wet season (Canzano *et al.* 2003), it is estimated that these newly emerged adults occurring during the early part of the wet season originated from eggs laid by diapausing mothers approximately 3-4 weeks earlier.

Reproductive diapause in *Euploea* in Australia is believed to be a significant survival strategy for the dry season in the monsoon tropics (Monteith 1982, Canzano *et al.* 2003), as early instar larvae of many *Euploea* species feed solely on fresh growth of their host plants (Clarke and Zalucki 2000, Rahman and Zalucki 1999), this being unavailable through the drier months (Braby 2000, Canzano *et al.* 2003). In addition, suitable nectar sources for adult butterflies are more readily available during the wet season, although it is thought that some dry season nectar sources can sustain these large populations during dry periods (Canzano *et al.* 2003).

On Dauan Island, the majority of specimens of *Euploea* observed at the very start of the wet season in November and early December were noted by Lambkin and Knight (2007) to be in a worn condition. This observation supports the theory that individuals have persisted by perhaps diapausing in aggregations on the island since the termination of the previous wet season.

While long-term, dry season aggregations of *Euploea* are documented in Australia (Kitching and Zalucki 1981, Monteith 1972, 1982, Valentine 1987, Scheermeyer 1993, Canzano *et al.* 2003), there are only brief mentions in the literature of other forms of communal roosting of *Euploea* species in Australia (Meyer 1996, 1997, Braby 2000, Lambkin and Knight 2007) and overseas, *viz. E. mulciber* (Cramer, 1777) in Taiwan (Yata and Morishita 1985) and *E. midamus* (Linnaeus, 1758) and *E. core* (Cramer, [1780]) in Hong Kong (Ackery and Vane-Wright 1984, Bascombe *et al.* 1999). One

report in Bascombe *et al.* (1999) similarly described *E. midamus* roosting communally at nectar sources of *Zanthoxylum avicennae* (Lam.) DC (Rutaceae). Despite the proclivity for *Euploea* in the monsoon tropics to roost during the dry season in Australia (Monteith 1972, 1982, Canzano *et al.* 2003), communal roosting by *Euploea* at nectar sources is previously unrecorded in Australia.

In America, nectar source roosting is known during migrations of *Danaus plexippus* (Linnaeus, 1758) (Nymphalidae: Danainae), where the butterflies pause along the way throughout their journey to imbibe on nectar. These opportunistic stopover sites are believed to be an important resource for successful migrations of *D. plexippus* (Brower *et al.* 2015).

While not strictly analogous to *D. plexippus* migrations, the phenomenon observed on Dauan Island in 2009-2010 could indicate that *Euploea* species can migrate out of their breeding environments *en masse* and are attracted perhaps from remote areas and arrested by discrete nectar-rich loci, such as in the case recorded here in mangrove glades of profusely flowering *L. racemosa* trees. If this is the case, then these temporary aggregations of *Euploea* might be migrations possibly originating from the nearby Papua New Guinea mainland, approximately 10 km to the north of Dauan Island. Moreover, crow butterflies were observed in January 2014, in numbers, flying in a northerly direction over the stretch of water that separates Saibai and Dauan Islands (pers. obs.). This observation does show that *Euploea* butterflies are vagile, at least between neighbouring islands.

The synchronization of several events which occurred in the early wet season of December 2009-January 2010 might have contributed to what appears to have been an atypical aggregation (when compared with other years), when *Euploea* butterflies were overall unusually common, especially as roosting individuals. This applied to species that are normally infrequently observed on Dauan Island (*e.g. E. leucostictos* and *E. netscheri erana*) and may further explain the occurrence of the two previously unrecorded species *E. w. melia* and *E. s. jamesi*.

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